Environmental Impact Assessment and Change Detection of the Coastal Desert along the Central Nile Delta Coast, Egypt

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Abstract

The world Deltaic areas are sensitive ecosystem subjected to both natural hazards and human interventions, among which is the Nile Delta. During the last few decades, the northern part of the Nile Delta have been subjected to extensive unplanned development projects affected and accelerated hazardous changes over an important and highly populated area in Egypt.

High spatial resolution Landsat and SPOT images representing the coastal desert along the central Nile Delta coast were used to provide information on coastal land uses changes of highly important economic value during the period 1984-2010. These types of land uses include wet lands, coastal sand dunes and coastal plain with the characteristic accreted ridges, in addition to agriculture, urban, reclamation, fish breading farms (as an anthropogenic inputs).

Results of processing the used satellite images demonstrate considerable growth of urban (2.8-19.0km^2), fish farms (7.0-53.3km^2), and areas of reclamations (17.7-132.2km^2) on expense of wetlands (73.8-4.5km^2), coastal plain (66.8—37.6km^2), and coastal sand dunes (165.4-9.3km^2). Agricultural land on the other hand shows considerable expansion from 93.5 to173.5 km^2 during 1984 to-1997, then gradual decrease to 164.2, 149.1, and 147.5 km^2 in 2003, 2006, and 2010 respectively.

Among the anthropogenic hazard that threats the study area is the removal of dunes which represent a natural defence against coastal erosion and the continuous shrinkage and drying of the Burullus lagoon by about 48% of its total surface area. The low lands at the southern coast of the Burullus lagoon are areas vulnerable to sinking in case of sea level rise, and aggravated with the human activities of fish farms and water logging problem.

Keywords

Environmental Impact Assessment; Coastal Desert; Central Nile Delta Coast; Egypt

Introduction

Nile Delta coast represents a sensitive ecosystem, affected by a wide range of natural and anthropogenic stresses. Among the natural hazard threatening the Nile Delta is shoreline change due to erosion and deposition which is a major concern for coastal zone management. Aswan High Dam is one of the major anthropogenic hazards, causing, among others, the deficiency in sediment and nutrients influx to the delta ecosystem, making the agricultural soil very poor, which requires heavy fertilizer applications. Intensive agriculture and farming has caused much of the loss of the wetland areas and habitats for many plants, birds and other biological life.

Furthermore, Nile Delta is a heavily populated area; and the population growth by a rate of 2% has made an increasing demographic pressure, resulting in a significant modification of the natural resource base. The study area (Fig. 1) is regarded as an investigation for urban growth to accommodate part of overcrowding delta governorates. In general, the coastal ecosystem has been constantly changing with considerable ecological pressure and deterioration of the natural resource. This growth enforced aggressive expansion in urban activities on the expense of the cultivated land. Fertilizer run-offs and industrial/ sanitary wastewater discharges are additional two major anthropogenic problems the Nile Delta faces. Adding to that is the heavy discoveries, exploration and production of oil and gas with related activities and industries such as gas liquefaction, petrochemicals and fertilizers all represent future stresses to the present hazards, (Ahmed and Donia, 2007; Ahmed et al., 2000).

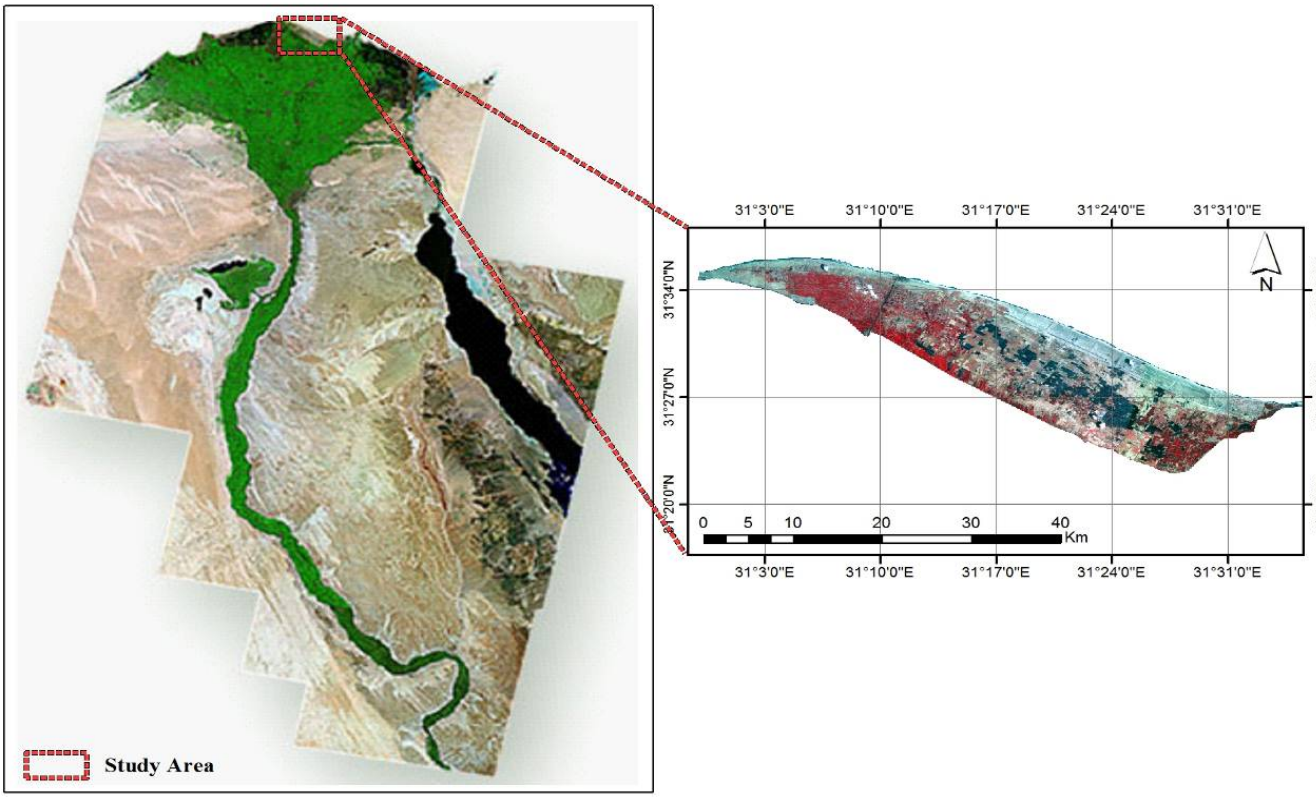

FIG. 1 THE EGYPTIAN NILE INCLUDING STUDY COASTAL DELTA AREA

The Government of Egypt has shown keen interests and commitment in addressing coastal environmental issues. Beside the active participation in regional and international activities, Egypt has established the Egyptian Environmental Affairs Agency (EEAA) in 1982, whose task, among others, is to establish environmental quality standards and to formulate the National Environmental Protection Plan. In 1994, the Law for the Environment (Law 4/1994) was ratified. Through its articles and executive regulations, EEAA plays a critical role in the preparation of the National Integrated Coastal Zone Management (ICZM) plan for the Mediterranean Sea and the Red Sea coasts, and has been instrumental in the creation and function of the National Committee for ICZM. When compared to 16 countries along the Mediterranean coastal zones, Egypt is found to be very progressive in its approach to coastal management.

For example, while there is no legal framework under which all applicable laws related to coastal zone are consolidated, the national laws on environment (Law 4/1994) and on protected zones (Law 102/1983) provide the basis for management of the coastal areas. These laws are always referred to as the consideration of any coastal development project, and are used as a basis for monitoring of coastal environment and the environmental impact assessment.

The aims of this paper are (1) to provide a recent perspective for land cover/land use changes that have taken place over the last 30 years, (2) to explore the environmental impacts of various human activities on the north central coastal area of the Nile Delta and (3) to draw attention to the existing hazards from both natural and human, aiming to promote regional sustainable development including various environmental conservation activities. The integration of coastal development and spatial information derived from high resolution satellite images, along with other field observations, will lead to the development of an integrated, GIS-based, information system for the Nile Delta coastal area. This approach is very effective for addressing some of the natural and anthropogenic hazards which will lead to a coastal management strategy in the region. This strategy can provide a framework for data acquisition, interpretation, and dissemination of data that can be extended to include issues faced in other coastal regions in Egypt, and thus serving as a basis to develop the national information system for ICZM capable to handle with these hazards.

TABLE 1 SATELLITE DATA CHARACTERISTICS UTILIZED IN THE PRESENT STUDY

Mission	Country	Instrument	Path/Row	Number of Bands	Acquisition	Spatial Resolution * (meters, at nadir)				Swath * (km)	Repeat Cycle (day)	Orbit altitude (km)
					Date	PAN	VNIR	SWIR	TIR			
Landsat-7	USA	ETM+	177/38	7+	Jan. 1984	15	30	30	60	185	16	705
Landsat-7	USA	ETM+	177/38	7+	May 1997	15	30	30	60	185	16	705
Landsat-7	USA	ETM+	177/38	7+	August2003	15	30	30	60	185	16	705
SPOT-4	France	2xHRV-IR	110/287	4+	September 2006	10	10, 20	10, 20		60	3	822
SPOT-4	France	2xHRV-IR	110/287	4+	February 2010	10	10, 20	10, 20		60	3	822
SPOT-4	France	2xHRV-IR	110/286-87J	4+	March2011	10	10, 20	10, 20		60	3	822

Material and Methods

Multi-temporal and multi-sensor remote sensing satellite data were used in the study. Two types of data sets were utilized to achieve the objectives of the present study (Table 1), the first of which is a set of Landsat satellite images acquired from the (ETM and SPOT-4 sensors). The ETM images were acquired in 1984, 1997, 2003 and the SPOT-4 images were acquired in 2006 and 2010.

Atmospheric correction, the first process to be applied to the Landsat and Spot satellite images, was carried out using the dark object subtraction method of Chavez (1996). Then, geometric correction was performed through image-to-image registration to the Universal Transverse Mercator Projection (UTM/zone 36 WGS 84) using a first-order polynomial transform. At least 20 prominent well-distributed ground control points (GCP) were carefully chosen in the master ETM, Spot images and matched on the other images, and then the nearest neighbour resembling method was applied. The root mean square error (RMSE) was less than 0.5-pixel for the registered ETM. SPOT images are less than 1.0 pixel revealing an accurate rectification; and the objective of this procedure is to automatically register the image to a sub-pixel level of accuracy. It is assumed that gross distortions, rotations, and scale changes will not be encountered. The registration is carried out on the shapes of significant objects in the imagery. ERDAS Imagine software was used to perform image processing of the satellite images. Two subset images were created in each of the ETM and SPOT images to show the boundaries of the study area during 1984, 1997, 2003, 2006 and 2010. In this study, Landsat ETM and SPOT images covering the north central coast of the Nile Delta in Egypt are enhanced by using high pass filter technique to enhance the geomorphologic features and also, land-use activities. Geo-referencing has been applied to the image to overlay the structural features extracted from the satellite images and topographic maps. UTM projection has been used for consistency purposes with other extracted line feature data.

Change detection algorithm used is based upon the unsupervised classification technique (Pilon et al, 1988). Methods used for the initial work were adapted from methods used for land-cover classification (Lillesand et al., 2008) and for change detection (Lillesand et al.,1998). Unsupervised classification technique was applied to the Landsat ETM and SPOT data for spectral bands. An arbitrary number of 7 classes are selected to represent all types of study area features and to enable the detection of any changes or loss of study area extent (from reclamation and changing land-use).

Because the MSS image lacks a middle infrared band (MIR), only the NDWI was applied using the Modeler Function in ERDAS Imagine. The NDWI was formulated as (Green–NIR)/ (Green+NIR), where the green and NIR represent the digital number of the green and near infrared bands in the MSS image of 1973. The resultant NDWI images highlight water bodies present in the study area. This index ranges from -1 to +1 with water bodies of high values (close to +1). As the TM, ETM+ and Spot+4 images have spectral bands within the visible, near and middle infrared spectra, thus the MNDWI was applied using the

Modeler Function in ERDAS Imagine in orderto eliminate any noise pixels. The formula of the MNDWI is (Green–MIR)/ (Green+MIR), where the green and MIR represent the reflection values in the green and the middle infrared bands, respectively. The output MNDWI images which range from -1 to +1 reveals the lagoon water in the images. Aquatic plants (floating and submerged) occupy substantial area of the lake and can produce misleading results of the water body area. However, the study of El-Asmar and Hereher (2011) reported that water indices are efficient to highlight turbid water bodies, which have submerged plants. The threshold value of water, which is the least pixel value that represents lagoon water, was then assigned. Lower values than the threshold are considered non-water bodies. The threshold was calculated in each NDWI and MNDWI map and recoded in blue colour. The number of pixels above the threshold value was counted together to represent the water body. The surface area was then calculated.

Results and Discussion

The study of land use/cover of the area in concern reveals the presence of 7 units including the wet lands, the coastal plain, the coastal sand dunes, the urban, the agricultural, the reclaimed and the fish breeding areas, in addition to several canals crossing the area, among which the most famous one is Kitchener canal.

The Wetlands

A wetland is a land area that is saturated with water, either permanently or seasonally, such that it takes the characteristics of a distinct ecosystem. Primarily, the factor that distinguishes wetlands from other land forms or water bodies is the characteristic vegetation that is adapted to its unique soil conditions. Wetlands consisting primarily of hydric soil which supports plants play a major role in the availability and quality of water, containing most of the water used to meet human needs. ESA's GlobWetland II project helps Mediterranean countries to monitor these precious resources. Located within the Nile Delta, the Burullus lagoon has undergone urban settlements that have flourished around the lagoon, and from 1973 to 1990 the area witnessed a sharp increase in aquaculture. As a result of increased waste water in the lagoon (largely due to aquaculture), there has been an overall decrease of salt marsh vegetation and in some parts replaced by reed beds. *Phragmites australis*(Cav.) Trin. ex Steud.' is believed to be the most widely distributed of all angiosperms. *Typha domingensis* (Pers.) Poir. ex Steud. is a plant that grows throughout the warm-temperate and tropical regions. In Egypt, it spreads in water bodies such as lakes, ditches and marshy places (Boulos, 2005). It is one of the major components of the vegetation stands along the shores of Burullus lagoon (Shaltout and Al-Sodany, 2008). *T. domingensis* is an emergent plant that is commonly used in constructing wetlands for enhancement of water quality in water treatment systems (Eid et al., 2012); El-Sheikh et al. 2010; Hegazy et al., 2011) due to its high growth rate and great capacity for accumulating nutrients in its tissues (Lorenzen et al., 2001; Newman et al., 1996).

Change detection of the surface area of the Burullus lagoon itself shows shrinkage in the total area of 1984, which was 3,850km^2 and became 1960km^2 in 2011 with loss of about 48% of the Burullus surface area (Fig. 2). Similar shrinkage was detected by El-Asmar et al. (2012b). The decrease in the lagoon surface area is attributed mainly to many factors, including: 1- Drying of the southern and southwestern fringes for reclamation activities for either agriculture or aquaculture (fish farms). 2- The landward movement of sand dunes and drifted coastal sand bar which would potentially reduce the lagoon area from the north. 3- The agricultural drains at southern periphery of the lagoon conveying turbid agricultural wastes rich in suspended materials. 4- Agricultural wastes entering the Burullus Lagoon are rich in fertilizers and nutrients, causing enhanced eutrophication and vegetation growth of sea weeds.

The correlation of SPOT-4 image of the Burullus Lagoon surface area with UNDP scenario of sea level rising by 0.5 and 1 m a.s.l (Fig. 2) shows shrinkage of the water body (blue color) as estimated from the NDWI and MNDWI (Fig. 2A). The latter is identical to areas vulnerable to the risk of sinking in case of sea level rising according to UNDP scenario (Fig. 2B). Most of the shrink areas south and southeast of the lagoon are actually below the present sea level and suffer a problem of water logging, which has forced the rural people to change the activities from agricultural to aquacultural one.

The wet lands in the study area (Fig.3A) show change detection (Fig. 4A), which reflects a general decrease from 73.8 km^2 in 1984 to 4.5 km^2 in 2010 with a gradual changes from 31.4, 25.9, 10.5km^2 in 1997, 2003, and 2006 respectively. The decrease in wetland areas is on the expense of the increase of agriculture and fish farm expansion.

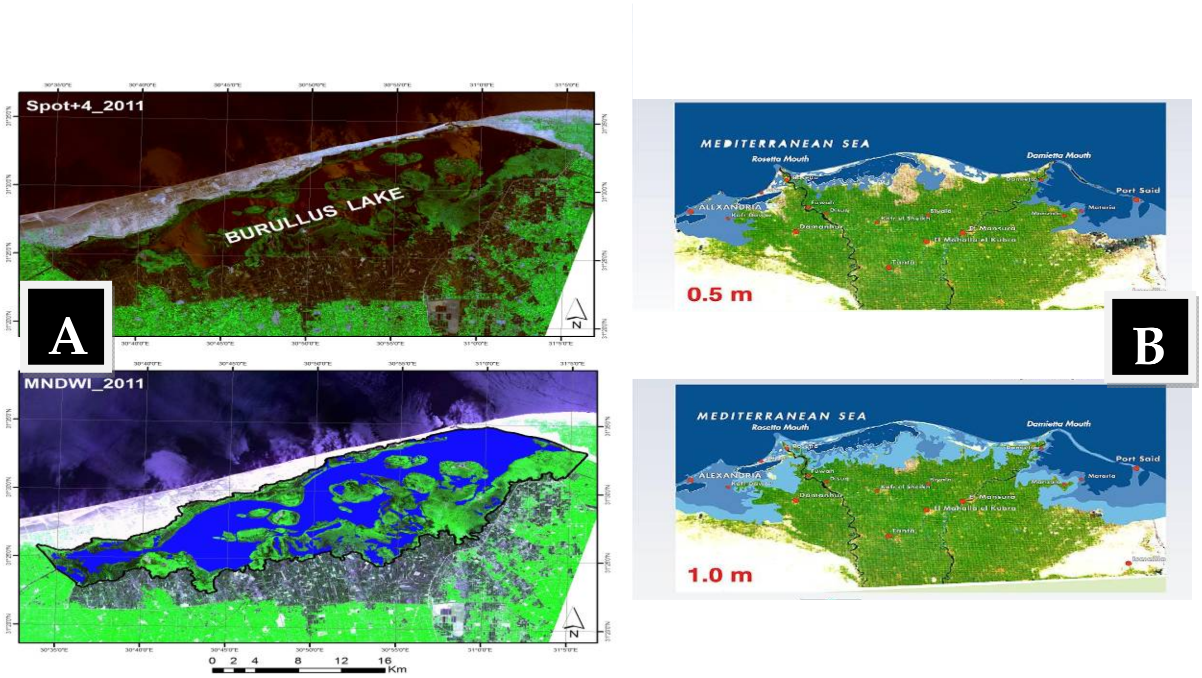

FIG. 2 BURULLUS LAGOON AS APPEAR IN YEAR 2011 THE SPOT-4 IMAGE (A) CORRELATED WITH UNDP SCENARIO OF SEA LEVEL RISE BY 0.5, 1M A.S.L (B) AND SHOWS SHRINKAGE OF THE WATER BODY (BLUE COLOR) AS ESTIMATED FROM THE NDWI AND MNDWI AND SHOW THE DRIED AREAS TO THE SOUTH, MOSTLY TRANSFORMED INTO FISH FARMS. THESE MOSTLY ARE BELOW PRESENT SEA LEVEL AND VULNERABLE TO THE RISK OF SINKING IN CASE OF SEA LEVEL RISE.

The Coastal Plain

The coastal plain (Fig. 3) or strand plain was described in (El-Asmar, 2000) with elevation ranges from 0.5-1.5 m above sea level (a.s.l). It is characterized by the presence of accreted beach ridges. These are coastal dunes that mark the position of former shorelines (Stanley et al. 1992), and parallel to the present shoreline with an elevation ranges from 1-3 m a.s.l., 12 km to the west of Gamasa, in addition, one of these ridges has local name of Tell (mound) El-Karaa having a characteristic brownish red colour with parts of fired building stones (Fig. 3B) and containing some pottery fragments (Fig. 3C). These were dated by El-Asmar (2000) as 3280±30B.P, 2800±50B.P, 2150±26B.P, and 1680±34B.P. and correlated with the beach ridges (6000-1500 B.P.) of Manzala lagoon (El-Asmar, 2002) and in part with that ridges located in Tineh Plain NW Sinai of Late Holocene Delta progradation (3000B.P.) (El-Asmar,1999). Earth verifying of these units reveals the presence of sand ridges related to Holocene shorelines. These ridges are partially quarried and contain several archaeological sites related to Neolithic III age (El-Asmar et al. 2012a).

The change detection shows that the coastal plain area appears decreased by 44% from 1984-2010. This figure is encountered by a decrease from 66.8 km^2 to 37.6 km^2 (Fig. 4B). It was a gradual decrease being 66.8, 66.3, 65.7, 39.1 and 37.6k m^2 from 1984, 1997, 2003, 2006 and 2010 respectively. The accounted decrease in the coastal plain area comes mainly due to urban expansion especially in resorts at Gamasa and Baltim and the industrial area of west of Gamasa.

The Coastal Sand Dunes

The coastal area between Gamasa and Baltim is characterized by a conspicuous geomorphologic feature which is the presence of coastal dune sands. The sand dunes are of two types: The old fixed dunes and the young mobile dunes. The old fixed dunes (Fig. 3B) characterized by an elevation not exceeding 5a.s.l.with little vegetation cover have a relatively higher content of very fine sand and silt, and are related to the first generation of wind-blown sands derived from the eroded old Sebennitic Promontory that ceases about 2500-2000B.P. (Stanley et al., 1992). The young dunes are mobile composed of fine sands, concentrated along the coastline and extend backshore to about 10 km. Two types of young dunes are distinguished; The Barchans or Barchanoids and The Longitudinal dunes. The Barchans are detected near Baltim and Burullus (Fig. 6A) where there has a plenty of sand accumulated along the beach and a narrow backshore (Ahmed and El-Asmar 2010, Ahmed et al., 2010) which are distinguished by a common wind

fences (Fig.6B) made of reeds to prevent sand movement from one side, and from the other side is to protect the agricultural activities. The rural farmers along this coastal desert are familiarized with the ways to cultivate these dunes based on seasonal rainwater and dredge sands from inter dunes to reach water table and get underground water (Fig. 6E). The most famous agricultural products include tomato, cucumber, and watermelon (Figs. 6F, G). On the other hand, the longitudinal dunes are concentrated along Gamasa coast and southward (Fig.3D) where a plenty of sand and wide backshore are present. The coastal dune area appears dimensioned in about 94% form 1984 being 165.4 km^2 to 9.3km^2 in 2010, (4D). A gradual decrease from 110.3, 61.5, and 64.3 km^2 from 1997, 2003, and 2006, respectively was detected, resulting from a coupled effect of reclamation and fish farm spreading.

It is very interesting to refer here to the natural defence work of sand dunes against coastal erosion (Fig. 6). The removal of these dunes along Baltim resort led to wave attacking the coast and collapse of some resort facilities (Fig.6D). When waves attack dune, sands move along the beach sea ward and return back to the beach by wind to the coastal dune with natural separation of sands into light and *heavy fractions. The heavy fraction* represents the black sands enriched coasts at Rosetta and Baltim (Fig. 6A).

The Anthropogenic Activities

Change detection along the study area showing several anthropogenic activities leads to several changes in land used/cover. The main observed units resulting from the change detection are:

1) The Urban

Although the urban expansion advances slowly along this coastal desert, still ambitious opportunities for this deserted sector to receive more populations from the Nile Delta Cities. Most of detected urban expansions, however, are on the expense of agricultural lands (Fig.3E). The urban area increased from 1984 to 2010. The change detection shows an increase in urban areas from 2.8 km^2 in 1984 to 4.6 km^2 in 1997, 5.6 km^2 in 2003, 9.1 km^2 in 2006 and 19.0 km^2 in 2010 (Fig. 5A). The urban areas concentrated at Gamasa resort with the new industrial area and in some spots near Baltim and Burg El-Burullus villages. In the framework of coastal management project, this desert is able to receive new planned cities with expected growth of population not less than 3 million citizens especially after the construction of the international coastal highway. Urban expansion with consequent overgrazing of agricultural area, and the operations of uprooted palm trees (Fig. 3G) which illegally exported to several Mediterranean countries in a corrupt example to exploit legal loopholes in the absence of state control, is example of a new risk the study area confronts.

2) Agricultural Area

Agriculture is one of the major activities encountered (Fig. 3F) in the coastal desert along the Nile Delta. Change detection from satellite images representing 1984 and 1997 reported an increase in the total agricultural area from 93.5 to 173.5 km^2. Since 1997, there has been a general decrease in the agricultural area being 164.2, 149,1 and 147.5 km^2 during 2003, 2006 and 2010 respectively (Fig. 5B). This decrease results from the fish farm expansion especially south of the Burullus lagoon. The cultivated areas show common deltaic products like tomato, cucumber and watermelon (Figs. 6F, G) beside strategic products such as wheat.

3) Reclamation Area

Reclamation is one of the major traditional activities present in the study area related to the culture of the rural people, the nature of sandy and silty soil and the presence of water for irrigation through several canals (Fig. 3G). Change detection for reclamation areas (Fig.5C) shows a general increase from 1984 to 2010. The area was 17.7 km2 in 1984 and increased gradually into 19.9, 56.6, 65.1, 132.2 km^2 for 1997, 2003, 2006, and 2010, respectively. The peak increase in reclamation activities appeared after the construction of the international coastal high way which made the study area accessible to investors. The acre price increases from 5000 LG to more than 200000 LG and in some location jumped up 1000000 LG.The expansion in reclaimed area is the result of the coastal plain and dunes areas.

Reclamation is one of the major activities presents in the study area due to the culture of the rural people, the nature of sandy and silty soil and the presence of water for irrigation through several canals (Fig. 3G). Change detection for reclamation areas (Fig.5C) show a general increase from 1984 to 2010. The area was 17.7km2 in 1984 and increased gradually into 19.9, 56.6, 65.1, 132.2km^2 for 1997, 2003, 2006, and 2010, respectively. The peak increase in reclamation activities appeared after the construction of the international

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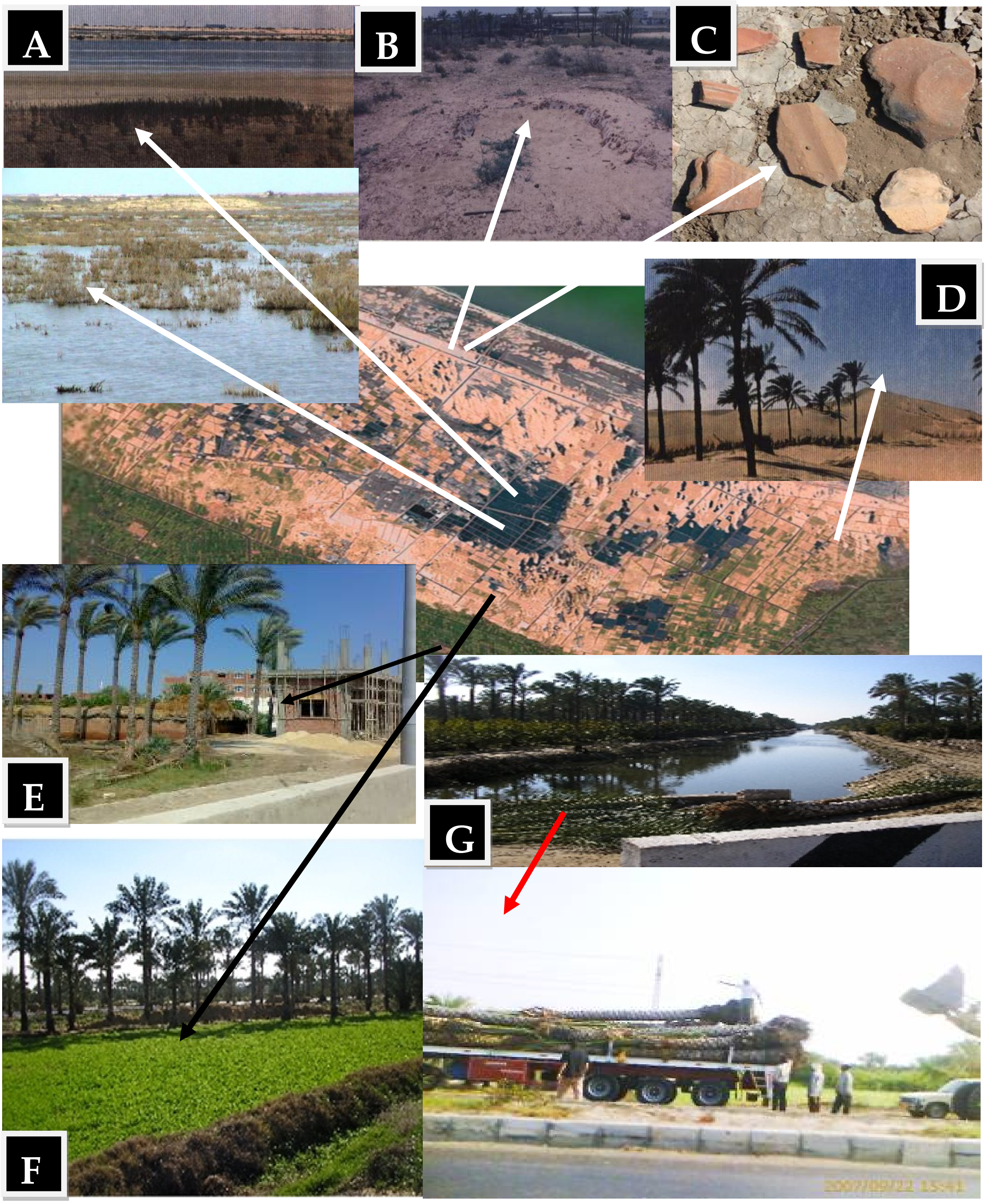

FIG. 3 FIELD PHOTOS ALONG GAMASA AREA SHOWING THE MAIN ENVIRONMENTAL UNITES AND HUMAN ACTIVITIES (A) WETLANDS, (B) FIXED DUNES WITH MOUNDS OF EL-KARAA (C) POTTERY FRAGMENTS ON EL-KARAA (D) LONGITUDINAL DUNE

NEAR GAMASA (E) URBAN EXPANSION ON AGRICULTURAL LANDS WITH PALM UPROOTING (F) EXAMPLE OF AGRICULTURAL LANDS NEAR GAMASA (G) KITCHENER CANAL WITH UPROOTING OF PALMS FOR ILLEGAL EXPORTATION.

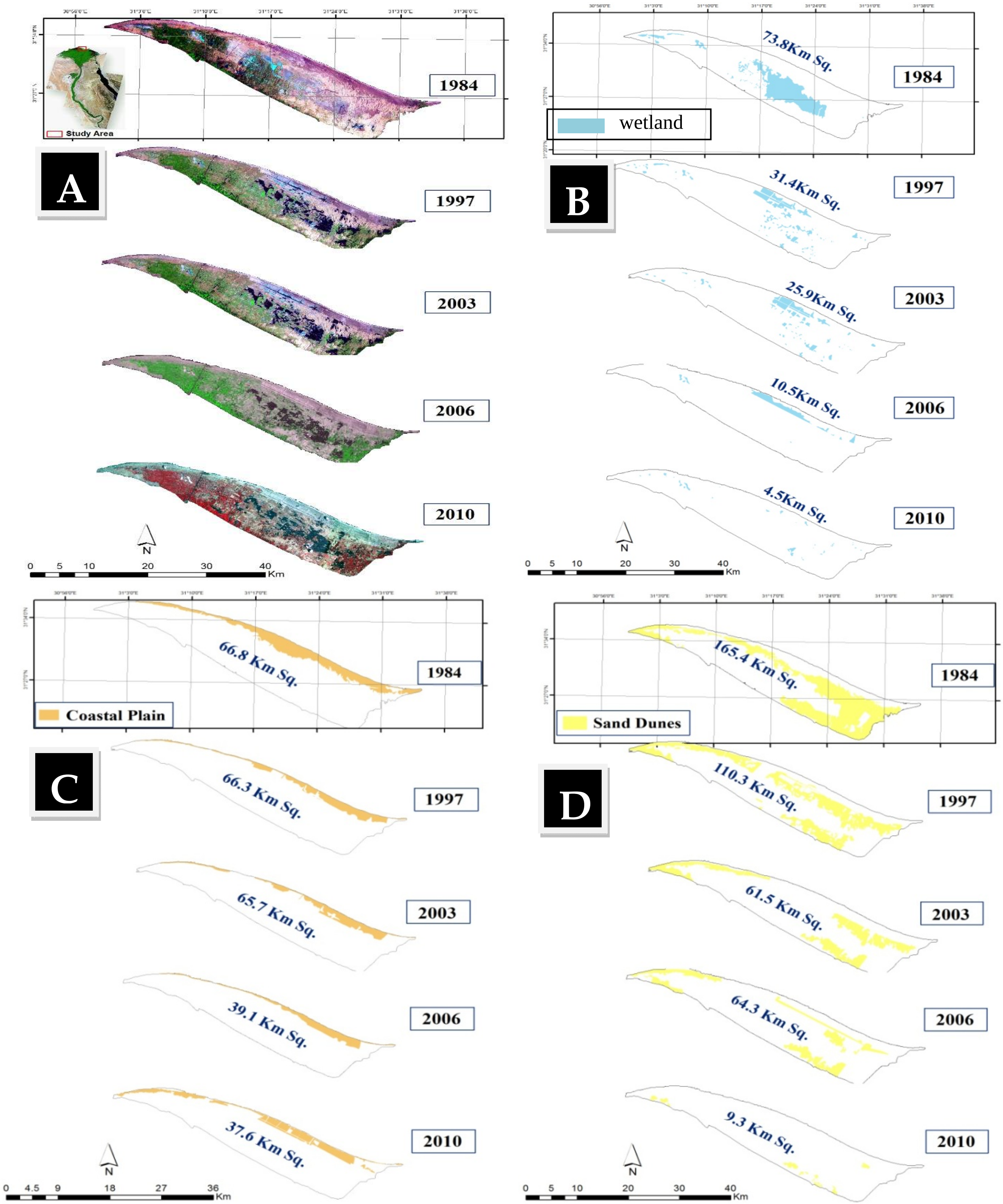

FIG. 4 CHANGE DETECTION OF THE COASTAL DESERT ALONG THE NORTH CENTRAL NILE DELTA COAST FROM 1984-2010 (A) WETLANDS, (B) COASTAL PLAIN, (C) COASTAL SAND DUNES (D).

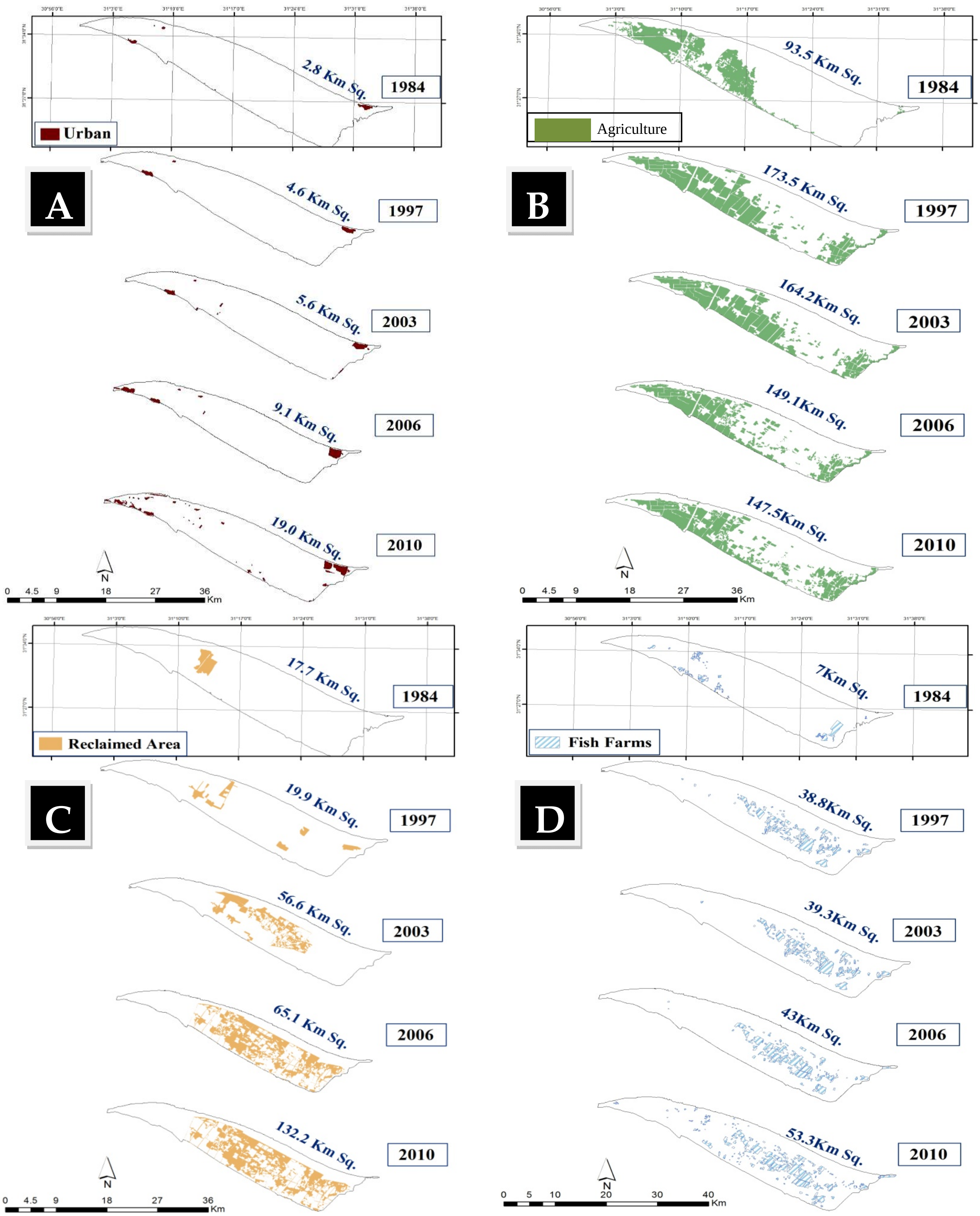

FIG. 5 CHANGE DETECTION OF THE COASTAL DESERT ALONG THE NORTH CENTRAL NILE DELTA COAST FROM 1984-2010 (A) URBAN, (B) AGRICULTURAL AREAS, (C) RECLAIMED AREAS, (D) FISH FARMS.

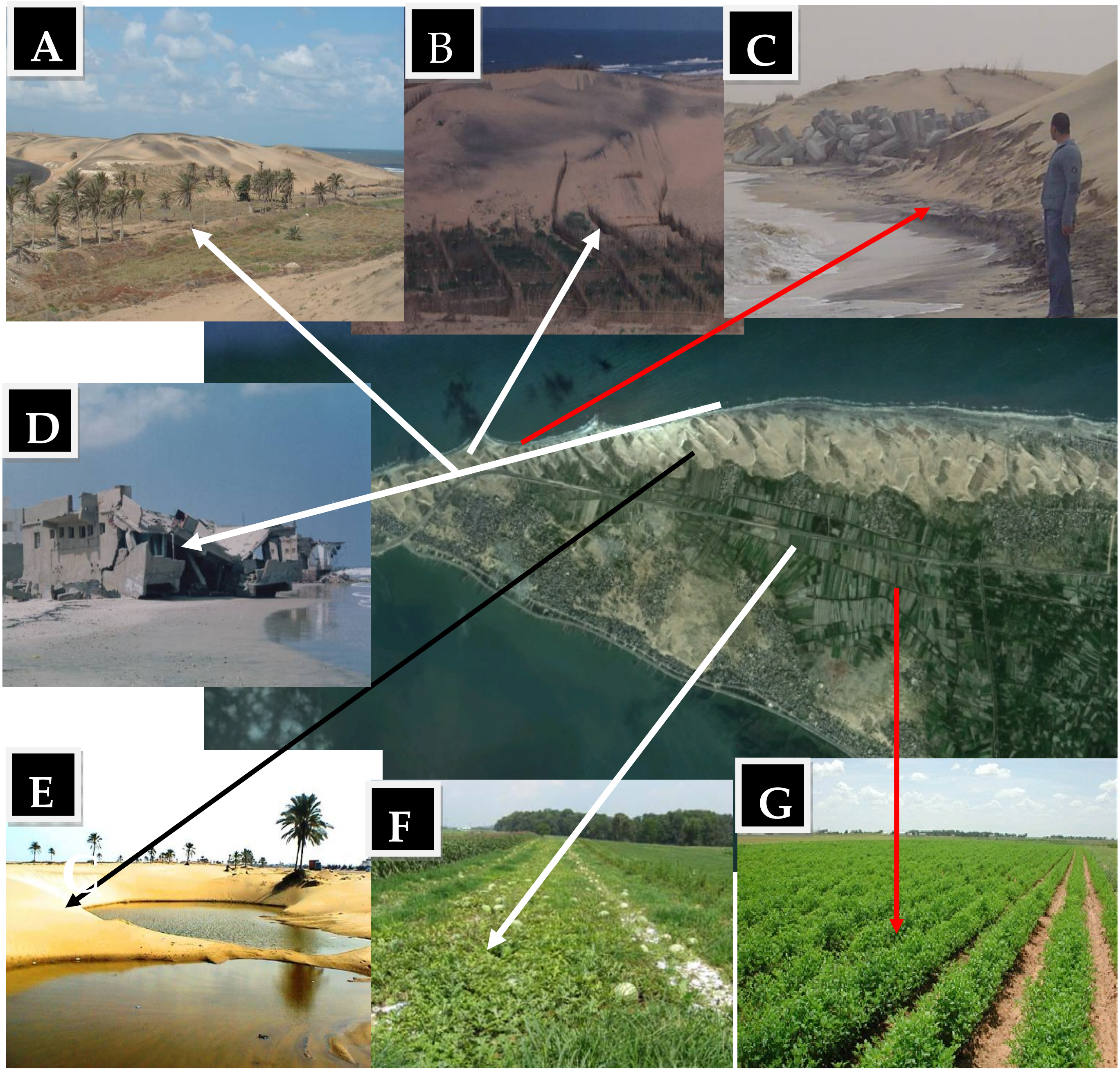

FIG. 6 FIELD PHOTOS ALONG BALTIM AREA SHOWING THE MAIN ENVIRONMENTAL UNITES AND HUMAN ACTIVITIES (A) BARCHAN COASTAL DUNE WITH TOP BLACK COLOR CONCENTRATED HEAVY MINERALS, (B) WIND FENCES AND CULTIVATION OF THE INTERDUNES , (C) SAND DUNE DEFENDED THE COAST FROM WAVE ATTACK AND EROSION (D) THE COAST OF BALTIM WHERE EROSION OCCURS IN THE ABSENCE OF SAND DUNE DEFENSE (E) INTERDUNES DREDGED SANDS WITH ACCUMULATION OF GROUNDWTER, (F) (G) EXAMPLES OF THE CULTIVATED AREAS WITH WATERMELON AND TOMATO FIELDS

4) Fish Farms

Fish breeding farm is a new activity comes to the study area during the nineteenth of the Last Century as an alternative activity to the agriculture one due to the high outcome/ac of fish farms compared with that of agriculture. Another important factor is that the rural people forced to shift to fish farm activities due to the problem of water logging southern of the Burullus borders. Area of fish farms increases by seven times from 1984 to 2010, being 7km², 38.8, 39.3, 43, 53.3km² for 1984,1997, 2003, 2006, and 2010, respectively (Fig. 5D). In addition to the previous reasons for fish farms expansion, part of the fish farms appeared on the expense of coastal dunes and plain.

Conclusions

Environmental impact assessment and change detection of the coastal desert along the central Nile Delta coast reveal detection of 7 units representing land use/cover including the wetlands, coastal plain,

the coastal sand dunes, the urban, the fish farm, reclaimed, and agricultural areas. Change detections of these units using multi-temporal and multi-sensor remote sensing Landsat and SPOT satellite data acquired for years 1984, 1997, 2003, 2006 and 2010 show considerable expansion in urban, fish farms, reclamation, and agricultural activities on the expense of coastal plain, coastal sand dunes, and wet land areas.

Most encountered environmental hazards are attributed to anthropogenic impact; of which are logging of areas around the Burullus lagoon due to waste water derived from different sources of agriculture, fish farms and/or domestics. Most of these areas are below present sea level and will be the most vulnerable to the risk of sinking in case of sea level rising. Removal of coastal sand dunes especially near the fragile area of Baltim and Burg El-Burullus may trigger another hazard. These dunes represent the first natural defense line against coastal erosion. Urban expansion with consequent overgrazing of agricultural area, the operations of uprooted palm trees and exported illegally to many Mediterranean countries in a corrupt example to exploit legal loopholes in the absence of state control, are examples of expected risk the study area faces.

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REFERENCES

Ahmed, M. H. and Donia, N. S. (2007). Spatial investigation of water quality of Lake Manzala using GIS techniques. Egyptian Journal of Remote Sensing and Space Sciences 10: 63-86.

Ahmed, M.H., and El-Asmar, H.M. (2010) Monitoring and assessment of coastal development along the Nile Delta coast using satellite images and GIS. 2nd Conf. on Contemporary Environmental Issues in Arid and Semi-Arid Regions (Envi 2010: Climate Change), Bibliotheca Alexandrina, Egypt, 3-5 July 2010.

Ahmed, M.H., Robert J. Nicholls, and Yehia, M.A. (2000). Monitoring the Nile Delta: A Key Step in Adaptation to Long-Term Coastal Change. The 2nd Inter. Conf. On Earth Observations and Environmental Information (EOEI), 11-14 Nov. Cairo, Egypt.

Ahmed, M.H, El-Asmar, H.M., and Ali, E. M. (2010) Short-term Assessment of Landuse Transformation and Shoreline Changes at the Northern Zone of the Nile Delta Coast, Egypt The 8th AARSS (The African Association of Remote Sensing of the Environment), October (25-29), 2010 Adesabeba.

Boulos, L. (2005) Flora of Egypt: Volume Four Monocotyledon (Alismatacea–Orchidaceae). Al-Hadara Pupl, Cairo, Egypt, 617.

Chavez, P. S. (1996) Image-based atmospheric correction-revised and improved. Photogramm Eng. Remote Sens., 62:1025–1036.

El-Asmar, H.M. (1999) Late Holocene stratigraphy and lithfacies evoluation of the Tineh plain, Northwestern corner of Sinai, Egypt, Egypt. J. Geol., 43/2: 117-134.

El-Asmar, H.M. (2000) Geoenvironmental changes along Gamassa Baltim Coast North of the Nile Delta, Egypt. Z. Geomorph. N.F., 44/1: 59-73, Berlin –Stuttgart, Germany.

El-Asmar, H.M. (2002) Holocene Paleoshorelines along the Manzala lagoon, northeast of the Nile Delta, Egypt. N. Jb. Geol. Mh. H. P., 6: 337-361, Stuttgart, Germany.

El-Asmar, H. M., Hereher, M.,(2011) Change detection of the coastal zone east of the Nile Delta using remote sensing. Environ Earth Sci (2011) 62:769–777.

El- Asmar, H.M., Ahmed, M.H., Taha, M.M.N., Assal E.M. (2012a) Human Impacts on Geologic and Cultural Heritage along the Coastal Zone between Alexandria and Al-Alamein, Northwest of Egypt. Geoheritage , 4/4: 263-274 (DOI 10.1007/s12371-012-0066-0).

El-Asmar, H. M., Hereher, M., El-Kafrawy S. (2012b) Threats facing lagoons along the north coast of the Nile Delta, Egypt IJRA, 2/2: 24-29 Academic Puplication.

Eid, E.M., El-Sheikh, M.A., Alatar, A.A., (2012). Uptake of Ag Co and Ni by the organs of Typha domingensis (Pers.) Poir. ex Steud. in Lake Burullus and their potential use as contamination indicators. Open J. Modern Hydr. 2: 21–27.

El-Sheikh, M.A., Saleh, H.I., El-Quosy, D.E., Mahmoud, A.A., (2010) Improving water quality in polluted drains with free water surface constructed wetlands. Ecol. Eng. 36: 1478–1484.

Hegazy, A.K., Abdel-Ghani, N.T., El-Chaghaby, G.A., (2011)

Phytoremediation of industrial wastewater potentiality by Typha domingensis. Int. J. Environ. Sci. Tech. 8, 639–648.

Lillesand, T., J. Chipman,, D. Nagel, H. Reese, M. Bobo, and R. Goldman, (1998). Upper Midwest gap analysis program image processing protocol. Report prepared for the U.S. Geological Survey, Environmental Management Technical Center, Onalaska, Wisconsin, EMTC 98-G001. 25 pp. + Appendixes A-C.

Lillesand, T.M., Kiefer, R.W., and Chipman, J.W. (2008). Remote Sensing and Image Interpretation. John Wiley and Sons, Inc., 111 River Street, Hoboken: NJ, ISBN-13978-0470052457.

Lorenzen, B., Brix, H., Mendelssohn, I.A., McKee, K.L., Miao, S.L., (2001) Growth, biomass allocation and nutrient use efficiency in Cladium jamaicense and Typha domingensis as affected by phosphorus and oxygen availability. Aquat. Bot. 70:117–133.

Newman, S., Grace, J.B., Koebel, J.W., (1996) Effects of nutrient and hydroperiod on Typha, Cladium and Eleocharis: implications for everglades restoration. Ecol.Appl. 6, 774–783.

Pilon, P.G., P.J. Howarth, R.A. Bullock, and P.O. Adeniyi, 1988. An enhanced classification approach to change detection in semiarid environments, Photogrammetric Engineering b Remote Sensing, 54(12):1709-1716.

Shaltout KH, Al-Sodany YM (2008). Vegetation analysis of Burullus Wetland: a RAMSAR site in Egypt. Wetlands Ecol. Manage. 16: 421-439.

Stanley, D., Warne, A., DAVIS, h., Bernasconi, M. and Chen, Z. (1992) Late Quaternary North Central Nile Delta from Manzal to Burullus lagoons. Egypt. Nation. Geograph. Res. Explor. 811: 22-51.